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AMERICAN JOURNAL OF OPTOMETRY

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SUSPENOPSIA OR AN INTERMITTENCY OF VISION*

F. McFadden, Opt.D., F.A.A.O.
Rutland, Vt.

The world is full of people whose vision is intermittent, which is of such common occurrence when properly checked for, that several cases will pass through each of our offices every week. As to its cause or the several causes which may accompany this condition there are many answers, to which a whole chapter should be devoted. It is a phenomenon of which the patient is usually quite unaware, although occasionally one will say that they seem to see with one eye at times.

One might say that if the patient does not complain, why bother with the test and further care of this difficulty. To those people I have no answer, except to suggest that they study further.

Intermittency is a condition of vision whereby a person sees with both eyes at times, while at others there is a period varying in duration from a fraction of a second to 5 and 10 seconds, often 30 to 60 seconds, in which there is a definite suspension of visual perception. The eye practically goes to sleep, rests, suspends, its function being wholly inoperative.

The mind sees through the eyes virtually as through two chinks in the wall. Perhaps one chink gunned north, the other gunned west. The view of the world as seen by the mind must be pieced together into a cosmic whole, so that our mental photograph will have all the varied characteristics of stereoscopic perception. The world viewed through either chink alone rises flat to the north, plane to the west. Its pictures are unallied being mere semblances of true factual conditions. It is only by our ability to see both sides of a subject, so far as possible, which produces in our minds true conceptions of objects in their relation to each other, and the spaces they occupy. A person having only one eye has an inaccurate conception of either far distances, or those which lie within reach of his arms, as our many tests disclose. Unless both eyes function uninterruptedly to produce continuous double pictures, which the mind superimposes, stereopsis is lost and the relationship of objects in the far or near field become mere figments of memory, belief, and imagination.

Eyes may be perfectly normal in every refractive sense, or they may

*Submitted for publication July 29, 1938.

be correctable to practically normal acuities, and yet the individual may be a visual intermitter (Suspenope). He may think he is looking out of both windows although one shutter may be closed to him unawares. On the other hand, the eyes may have low visual faculties which are not materially improved by lenses, and yet function without this interruption, thus forming images by which the mind accurately judges the relative position of objects from exceedingly dim and beclouded details.

There is probably no reasonable doubt whatever, that intermittency takes place much further back than the retina, for we cannot truly say that we see *with* our eyes, but merely see *through* them. We may burn our thumbs, the pain is in the brain or the mind. The transfer of pictures from two separate entities into a composite does of course, not take place in the Commisure nor probably in the Optic Thalmus, but quite likely in the geniculate ganglia, although we shall discuss this factor presently.

Fortunately we are rapidly passing beyond real "eyeball testing," and although we are seeking every possible refinement in this portion of the work, we are becoming more critical of ourselves with respect to the form, size, color, relative position, and details of the two images. The little we yet know of Eiseconia is well founded proof of the fact that the two pictures of unequal size cannot blend into a perfect view.

My readers are all familiar with the curved mirrors, shown at seashore resorts and other places of amusement, in which a tall man becomes as squat as a squash at one turn of his path, and a mere flag pole at the next bend. Two photographs of himself of this type, placed one upon the other, would not resemble him in any sense. Two eyes with unlike astigmias, two eyes one of which is myopic, the other hyperopic, or two eyes combining these errors, must produce upon the background of the mind minute grotesques of similar character, but the mind is called upon to understand where these objects exist, whether they represent comfort or danger, food or flowers, and if they belong in the extreme or the near foreground.

Nature knows no such thing as size. The largest object in the Stellar universe—to the mind—is as perfect in every mathematical detail as anything about us. Peeking through the microscope we discover small worlds of equal perfection. Mere size does not constitute perfection or imperfection. We cannot say because a picture is very small, its image upon the retina or the mental background is of no consequence with respect to perfection of detail. For millions of years we have been building up this function of sight and mind as the very foundation of a factor of safety, self-existence, and futurity. Only the fittest will survive, and fitness means safety, life, endurance, and offspring.

What we seek is sufficient accuracy and comfort of vision, and relative safety. Unless the pictures are not merely of set relations, but are concomitantly placed one upon the other, such for instance as a hyperphoria, an exophoria, or an esophoria, or combinations of the difficulties of which they engender are quite likely to produce an interruption in

either one or the other visual functions. This bears more particularly upon that portion of human society, in which you and I are perhaps today more keenly interested than any other, with the vision of the motor car driver in connection with the 36,000 fatalities, 128,000 injuries, and million dollar losses last year.

All the usual run of optometrists, fundamental clinic foundation examinations, tests, and rechecks, are taking no heed whatever of those cases in which vision lapses for a minute, a moment, or a second, and during which periods of interrupted "binocular" visual perception in which the function of thereopsis does not exist.

The average speed of motor cars today, is from 50 to 75 feet per second. If the driver has a lapse of stereoscopic vision in either his dominant ocular function, or his non-dominant ocular function, something may happen. Until this visual anomaly is recognized in routine work, and is carefully checked in, or checked out, our work of examination is that much inadequate. Before beginning a thorough-going discussion of checking for intermittent visual perception (Suspenopsia) there are certain things which should be canvassed.

It is the mind which sees. The mind sees through various brain portions or anatomical units. The brain is a complex organism whose faculties we have no time to discuss, other than some of those connected with vision. The retinas are merely extensions of the brain which have come out to see in precisely the same sense as the naked fibrils in the base of the nose are exposed nerve fibers, extending from the olfactory lobe. One set of fibers, those of the retina, are attuned to light vibration frequencies. Those of the nose are in some manner chemical analysers. Certain portions of our body contain nerve tendrils whose function is to perceive temperature—heat, cold and slight variations—while other fibrils are adjusted for contact, such as weight, pressure, light touch, tickling, and lesser contacts.

The visual sense is very much more complex than we yet believe. Merely because an eye sticks out in front does not make it aught else but a feeler. The optic thalmus is that portion of the thalmus, or switchboard, or cross-over, or central intelligence system, in which the function of the two eyes is somehow blended, transposed, and fused into a composite. It is doubtless in this organ of the brain where every picture is broken down into its fundamental elements, from which secondary impulses originate. One sensation is projected to the area of visual memory for comparison as to size, color, and other characteristics. From this place again, doubtless originate those impulses which control the ocular movements in all their complexity, and again, from this organ there extends still further ramifications to the Parietal regions of the brain which is particularly adapted to take note of not merely a direction of projection, a direction of motion, but also as to whether a retinal picture is of an increasing size by approach, or a decreasing size by recession, or whether the picture of the object passes at some oblique. Here is founded that sensation of safety or danger.

Still other radiations from the optic thalmus extend to the cuneus in the hind brain. This projection to the calcarine fissure of the cuneus are without the slightest doubt straight, positive, direct, and sole connections with the fovea centralis, and the surrounding macula of the retina. The foveal nerve terminals are all cones, no rods. The peripheral field of the retina is all rods, apparently, with a few cones scattered about. From these factors and many others, we will not here cite, it is a virtual fact that a single eye as an organ, is a dual instrument. The peripheral field perceives its optical picture from the same focalizing elements as the fovea does, but with its widely separated rods, and interspersion of a few cones, its perceptual faculties are quite unlike those the central area has, moreover, the brain area to which *its* message is sent, is wholly different from that from which the fovea derives its inspiration. The rods are *loosely* packed by comparison with the crowding of the cones. The result of this loose arrangement and tight packing of nerve elements gives one the faculty of *macro*-scopic* or *micro*scopic* vision, in the outer and central fields respectively. Thus when we see with merely one eye we may consider that we do not "see double," but we double-see. We take in two similar, and yet very unlike types of pictures, one of which is concerned particularly with things in motion, motion pictures, and movements of the world about us on all sides, stimulated by color, and a thousand hues, by light, and shade in ten thousand gradations, while central vision is deeply analytical because of its ability to pick out minutia. Now all these functions take place so rapidly in the eye, the thalmus, the parietal region, the memory region, and the cuneus that they must be sensed, acted upon, the slate wiped clean, and a new impression imposed in the tenth, the fiftieth, the hundredth, and lesser fractions of the unit second of time. Thus TIME is a *distinct* element of the function of vision which we can no longer ignore, for there is fast vision, slow vision, and all grades of speed depending not merely upon the adequacy of illumination, but also upon keenest of mentality, personal reactions, sensitiveness, and the force which they impress upon judgment.

We have spoken of "ocular" vision as being the usual idea with regard to human sight. One may be said to have mon-ocular, or bin-ocular according to whether he has one or two eyes, but there is still another factual consideration to be given to the sensation of sight for, as we have seen, should one of the pictures lapse for any duration of time there is not the slightest shadow of doubt but that the retinal picture is perfect, that the rods, and cones receive and transmit to some place in the brain. Now if this transmitted picture instead of being acted upon or sensed, is merely laid upon the shelf, for some obscure reason, we cannot say that the person does not have bin-oc-ular vision, but that he is acting upon a basis of vision from merely one eye. It has for a long time been apparent that we need a new term descriptive of a condition in which *both* pictures are transmitted, and *one* is given heed. We

*Macro- large, Micro- small.

propose the word Optralcy, which will receive the prefix Mon- or Bin- as the case may be, thereby indicating whether one or both retinal pictures after reception in the optical thalmus are properly switched in, being transmitted to all those portions of the brain for concomitant acceptance. As an actual every day working fact one may have every faculty of true "binocular" vision, and still react with only one eye at a time, in which case they are virtually without mental vision from both the east and the north walls, and exhibit monoptal perception.

There is an enormous amount of "business" which necessarily follows when a retinal focalized picture is transmitted to the mind, through various functions of the brain. It is, of course, a well known fact that the picture itself ceases at the retina, but that it is broken down into an almost inconceivable number of component parts which might perhaps be likened to the dots and dashes of telegraphy, or the unlimited number of sounds of a spoken language, or to a mass of language as garbled to our perception, as Chocttaw Indian or Ancient Hebrew. These impulses are not pieced back together as pictures from the outer world, but are assembled in some strange fantastic manner by which we understand their meaning, and are reflected by visual memory centers to the mind. Should there be a lapse in any of these messages, or a failure to understand them, or a failure to properly assemble them, or to assimilate them there is a certain factor missing to the memory, and perception centers of the mind. In view of this fact it would not be at all strange that two retinal pictures of unlike form, caused for instance, by a difference in the size of focal images, or to distortions from astigmatic errors, or to the lack of correct pointing by the eyes as well as other factors, would cause such discrepancies in the reception of visual impressions as to make concomitant vision either difficult, or in some measure impossible. It is no wonder that perfectly normal people whose eyes are correctable to a high visual acuity, but who may have slight discrepancies, such for instance as, a low exo condition, or some Hyperphoric error, have never really acquired stereopsis, or have merely experienced it fleetingly. These people are, of course, truly Bin-*ocu*lar, but they may have interrupted Bino*pt*ral vision. Hence during any lapses of the image from either eye they will be half-visioned and naturally, without stereoscopic sense—virtually "One-EYED-Rileyes."

The writer selected "Suspenopsia" as being reasonably similar but wholly unlike to the term Suppression, in the belief that the new term would be suitable. However, he used at that time an alternate term: "Intermittent Visual Perception," and it is proposed that those who find difficulty in carrying the former two words clearly in their minds may substitute to themselves as *Intermittency*.

The question will be constantly occurring to readers: "How shall we go about it to find Intermittent cases?" to which the answer is "You don't have to go about it to find them, or look for them, they tell you themselves in no uncertain terms." For instance, in making let us say the maddox test, which is commonly done with the maddox bar, and the

maddox point of light, the sitter is required to *give heed* to the small light, after which he is to state whether the vertical streak is to the left or right of the light, or *on* the light. In making this test for Ocular poise it is of course, essential that the eyes come to rest and both indicate their relative positions to each other. How common it is for the patient to remark that he cannot *see* the streak. "Oh, I see it now, it's gone again, I can't even see where it was. Oh, now I see it, but I only see a part of it. It keeps coming and going, Doctor. Now I see the streak, but the little light has gone out. You must be doing something to the light or the instrument that makes one of them vanish every few seconds." Perplexed by such comments and while taking the data for ocular poise it would not be at all surprising if you became vexed, and in very gentle but firm terms *insisted* upon the patient paying attention, and telling you exactly what he sees, cease making an exhibition of himself, or trying to fool you, or waste your valuable time with mere chatter. Upon further assurance by the patient that he is honest in all his statements you became more deeply vexed than ever, and almost gave him a mental shaking up, or if it were a child perhaps nearly came to a physical shaking down. At any rate, you exerted all the intensity of your will to impress upon him that he must exert his full power of mind, and will his attention to SEE *both lights continuously*, and yet in spite of all, the same conditions recurred with indisputable frequency. Perhaps nonplused you changed the maddox bar to the other eye to reverse the conditions, and yet either the streak or the light, or both of them, alternately acted in the same manner. How often have we encountered these conditions to our frequent vexation, and probably written upon the Rx blank, "He Suppresses." Nothing of the kind. He could not suppress. It was beyond his control (and yours), but Intermittency (Suspenopsia) was present.

Still unbelieving you changed the type of test by producing vertical diplopia, perhaps using a much larger fixation light, and required the patient to distincly state whether they saw *both* lights, so that you might place one vertically over the other. Again one of the lights would vanish! To still further check yourself, and the patient, perhaps you resorted to the maddox double prism, thus producing two lights for one eye, with the other one taking up a position somewhere between them. Again vanishing occurred, but *this* time another puzzle was presented, and the patient would perhaps state that instead of seeing *three* lights all the time, one of them goes out, vanishes. You perhaps think he has wiggled, moved, sagged in his chair, or gotten out of alignment, and in some vexation readjusted him with the admonishment to keep his eyes in central positions. Still the same answers. Nonplused as to what was going on, you slip a red filter before the maddox double prism so as to have an upper and lower red light with a white one in some intermediate position.

We have virtually been making unwitting tests for Intermittency for a century, but although the replies given in the subjective procedure

have told the story, we were not prepared to understand the import of the replies. It is of course puzzling to us to comprehend how two eyes of a normally alert, active, healthy, keen minded person, can *look* at an object with both *eyes* wide open, with the corrective lenses in place if required, and fail to *see* with both eyes simultaneously. Yet the facts lie before us both in the individual, and the record they may give us, that when the images of unlike color are sufficiently dissimilar, to be descriptive to us as coming from the eyes separately, that they are not seeing continuously and uninterruptedly with them both. As to possible causes, we will discuss them at another time.

There are almost limitless ways of making tests for Intermittent Vision. The routine maddox bar of light with the spotlight is the first one likely to come to our attention, from the fact as previously mentioned that we are endeavoring to loosely check the visual poise of the eyes, and receive as a by-product statements indicating that there is interruption of vision. The maddox bar light extends over a vertical arc in the retina of perhaps 20 to 40 degrees. If we use a prism causing vertical diplopia, and a fixation light of 5 mm. or 10 mm. diameter the retinal areas stimulated are, of course, exceedingly small. If on the other hand, a maddox double prism is used before one eye, thereby producing two small images, the areas are also small.

Another method is that of using two maddox rods with bars of light horizontally placed, with the vertical displacing prism behind one or both, with just sufficient power as to cause diplopia, or to break fusion. Still another method is that of using the maddox double prism base horizontal in combination with the maddox bar of light extending horizontally, thus producing two *long* arcs on the retina. Before the other eye there may be placed a single maddox bar of light. This will normally assume a position either mid-way or somewhere between those of the first eye. It will be noted in connection with the maddox bars of light, or ribbons of light, that the retinal areas being tested are far greater than those in which merely the maddox spotlights are projected upon the retinas. We shall come to further consideration of this fact presently.

Another convenient method is that of using single maddox bars, or ribbons of light, placed at X angles of any convenient number of degrees. If our right or left eye slips, it is readily seen which one is doing the vanishing, by the position of the maddox rod. As to the amount of retinal stimulation attainable, this is readily altered by enlarging or reducing the diameter of the spotlight. I will describe an improved illuminant, which has every right to be adopted by our instrument manufacturers, and disseminated widely among the refractionists. We are confined to a mere point of light at the farther side of the room which can be altered from about ⅛ of an inch to ¾ of an inch. The distance which this light travels to the instruments, reduces its candle power tremendously, and the dispersion which it suffers from the two surfaces of every lens and prism, as well as in the media of the eye itself, reduces the volume of light upon the stimulated retina to a very low degree.

For this reason a large disc 5 inches in diameter of daylight frosted glass (blue glass), before a frosted electric bulb having a white reflected substance behind this bulb affords us a large area, and a usable volume of parallel rays, which will be useful for a great many tests in the refracting room, aside from those for Intermittency.

The use of this light, either direct or broken up with one or both maddox rods, affords large areal stimulation which is exceedingly useful, not only in Intermittency but in Amblyopic work. Another exceedingly useful source is a Lin-O-Lite tubular lamp, mounted in such a way about midway of the tube that it may be placed vertically or horizontally by turning upon an axis. This tube should be painted over with black, and a portion of the paint removed the whole length of the tube leaving a space 5 mm. wide as an auxiliary to the maddox streak, and the large spot of light.

This will be found very useful in comparing the *volume* of light which is emitted by either of these new illuminators, and their reception upon the retina. They are a hundred to one better for much of our work in many departments of Optometry, not merely in Intermittent Vision, but in Orthoptics in all its various phases. The small lights usually found are scarcely more than toys since their intensity and volume is absurd.

One more useful adjunct is a four-lens handled arrangement having upon one side of a stem complimentary colors of red and blue-green glass, and on the other side another pair placed in reverse position. Care should be exercised in securing lenses having respectively, red 7500 A U, and blue-green 4500 A U.

With this tool we can instantly settle many points as to which eye is being investigated, by placing this before them so that they may tell which colored light is referred to; thus indicating to the Refractionist the facts of the eye which he wishes to test. It is well also to have two other trial red and green ring filter lenses of a standard size, which are readily inserted into the phoropter head.

MAKING THE TEST

The first indication of Intermittent vision will undoubtedly be when making the so-called maddox test for ocular balances, in which as before stated the patient is likely to remark that the streak vanishes and returns, or that there is an interruption in the spot light. This is our first hint of Intermittent Visual Perception. We should first proceed to obtain necessary data for Ocular balance, together with ductions, after which we shall next investigate this anamaly. To do so we again ask the patient to fix upon the spot-light. Here we must pause, and instruct him that he must give his whole, undivided attention to the spot of light itself, never for a moment letting his earnest gaze falter or slip aside from the direct station upon this small area of light. Next ask him if he can do this, and require him to do it for a moment to make sure that he understands thoroughly. As soon as he assents to this, ask him if he also sees the maddox ribbon of light, to which he will say "yes."

As soon as he has settled in his own mind that he can attend to two things without difficulty, tell him to use *two* words, only *two* words, no more than *two* words. (This is going to require careful attention, and no patient can give it the proper heed while chattering along, using unnecessary verbage.) These two words shall be merely one syllable each: GONE and BACK. As soon as this is explained, and *definitely* understood by him, have him tell if the maddox ribbon vanishes by saying "gone," and when it is again visible, he is to say "back." Now the Optometrist may make a note of these recurrent appearances and disappearances of the retinal picture of the eye investigated in one of three ways. He may take a mental note that the interruptions occur very *in*frequently, perhaps not more than 2 to 5, or 6 in a whole minute while he holds his watch in his hand, or he may make more definite record of the interruptions by saying to himself or aloud, 2 seconds gone, 12 seconds back; 1 second gone, 17 seconds back; 7 seconds gone, 2 seconds back, etc. After one or two trials of this nature he can set down upon the examination chart the fact that the eye test shows interruptions of approximately so many per minute. One full minute, or two full minutes should be given to each eye if there is Intermittency. After the first eye has been checked, move the rod from before it, and place it in front of the other eye repeating the test. Mark each one appropriately on the chart, right or left Intermittent Visual Perception. It will be noted in *many* cases that the interruptions, *if* they occur at all, are of exceedingly short duration. A mere off-flash, or it may be said to twinkle-out, and that the one condition is consequently nearly without any interruption for convenience in routine recording. For recording these conditions the writer has arranged a schedule indicating, under the "First Order," those where the interruption does not exceed one or two seconds. Under the "Second Order" those interruptions from two to five or six seconds. Under the "Third Order" those interruptions carrying upward to fifteen and thirty seconds. The "Fourth Order" is absolute, where the object vanishes and does not return until some outside stimulus is applied. This will be described at length in another chapter. These are mere convenient checking data that lack the scientific aspects we shall discuss later.

Now we shall be told, by almost the first patient in our chair, some rather puzzling and peculiar things. Quite likely he will remark that the maddox ribbon of light does not vanish, but fades and returns. Sometimes we shall be told that it fades *almost* out, but is still perceptible. In other words it wanes and waxes, and may be recorded as Wn. and Wx. Another patient will say that the upper half of a vertical streak vanishes and sometimes they alternate. At times either the upper half or the lower half may wax and wane, while the other end remains of the usual intensity. Still another puzzling case insists that the very center of the light vanishes and returns, while both the long ends remain fixed. This of course, is a clear indication of Intermittency in the Macular area, rather than of the field. Another check test consists in placing the maddox ribbons of light at oblique positions, like a letter

X, with a red filter behind one, and a green behind the other, with the intensified volume of light previously described. This gives us a large arc for study of both eyes simultaneously, so that if one color vanishes, we are instantly told by the patient that the red streak is missing, or the green streak is missing, or some portion of it, by which we instantly know which eye is the greatest offender.

Another check consists in placing both maddox ribbons horizontally, and using a vertical displacing prism, either with or without the filters. We will then be quickly told by the subject that the upper, or the lower, ribbon vanishes, and the time that it is missing. It is readily recorded because he tells us which color is lost. Now the maddox bars produce ribbons of light of less intensity than those obtained from the Lin-O-Lite Lamp. If this line is rotated to a horizontal position in the test cabinet, and a vertical displacing prism together with the red and green filters are employed, more intense light streaks will fall upon the respective retinas. It is well for every refractionist to have just as many tricks in his bag he he can assemble, and not only this, but he needs to know all the variations and combinations, for he is definitely certain to require a variety of responses. They should be checked against each other in rapid succession. This may read like a long and complicated procedure, although the facts are that rarely more than one or two may be required, yet the actual time required is practically negligible.

We have spoken of a third method. There are times when we would like to know more definitely what the patient sees, how he sees it, when vision intermits, and returns, and precisely how he would write it out himself if he could do so, for it must be understood that by the time a subject perceives a fact, formulates the word and expresses it vocally, and we have received the intelligence, that a lot of useless time is involved. Therefore, any record we may later attempt to set down purely from memory is not very accurate. For this reason the Kymograph has been devised, so that a drum with a paper surface revolves at a slow fixed speed under the control of a small electric motor. Above this drum are placed pencils, or pens, which contact with the paper. The patient instead of talking, now uses his finger to pull a string which makes a zig upon the drum. As soon as the light returns to visibility he relaxes his finger, and the indicator makes a zag mark upon the drum, so that the record of the eye may be graphed over a period of 2 or 3 minutes as zig-zag.

Now it so happens that the motor area of the brain which controls the arm, hand, and index finger movement of the dominant hand, is exceedingly close to, and upon the same side of the central sulcus of the brain as the dominant eye, and perhaps both eye centers, so that it takes far less time for the subject to merely pull and relax his finger, to produce an authenic record, than for it to pass by word of mouth to him and us. It takes but a moment to plug the Kymograph into an electric outlet, and the motor starts immediately. The loop is placed over a patient's finger, and after a brief instruction he is told not to talk, but to merely pull the string when the light goes out, and to relax the string when the light

returns, while we let his record run on for the length of the drum. We slip the maddox bar before his other eye, and proceed to take a second graph along side the first one, on the same sheet. This sheet is given a control interval of 5 seconds so that we may readily judge by comparison the *on* and *off* intervals, or times of Intermittency of the eyes. This strip of paper is removed from the drum and attached permanently to the record chart.

It has been found that some subjects are sufficiently alert and dextrous so that the Kymograph record may be recorded duplex. To accomplish this one cord which controls this operation of one of the recording pens will be operated by the right index finger while the other cord and pen are operated by the left index finger. The patient thus prepared will be instructed to give heed to let us say the red light associated with his right finger letting him perhaps think of R which is the first letter of each red light, while he also is to attend upon green and left when he will pull or release his left finger. Only a few patients are sufficiently keen minded to keep this record satisfactorily. However, many people can and do demonstrate this ability, and when we have such a patient it is sometimes learned that there are periods of time during which the lapses of visual perception occur simultaneously in both eyes. These periods of Suspension will in some cases over-lap for a sufficient time to show clearly upon the graph that they are psychically blind.

Not only are these cases shown by the Kymograph, but we may at times elicit the information from the patient that they do not see anything even when they are looking at it. When asked to be more specific in such statements their replies boil down into the fact that the overlapping periods of Suspenopsia are Binoptral, or mental blindness.

The writer distinctly recalls one hotelman who had spells of this nature while driving his car, stating that he was blind for a time, and that he was obliged to drive up to the fence and remain quiet until recovery took place.

From a long series of intricate experiments I have developed that we do not see all over the retina *all the time*, but that we see with a part of the retina, perhaps with only a few cones in one region, or rods in one region, while those contiguous are in the resting state. For instance, I place a small diamond in a central position before the eye, so that a minute fixation light is reflected upon the external and internal surfaces of the diamond, thus producing a great many small, sharply defined points of light. We should expect to see all these points without interruption whereas, as a matter of experimental evidence, some of these lights vanish and return much as stars may be said to twinkle in the sky. Not contented with this minute vanishing light, I pierced a thick black paper with an electric spark, and placed this orifice directly in line with a single filament of a 40 watt unfrosted tungsten lamp. Again these sparks of light twinkled in and out in the field.

We have carried this to still greater refinement by using a star on

a clear night, and an arrangement whereby many points of this infinity light are distributed over a limited area of the retina, and again the twinkling, not of the original single star, but of the multiplicity of points takes place, now here, now there, now anywhere, so that it suggests to one's mind the strong possibility that the twinkling of stars is not due to the star itself, but that the cone or rod upon which this single beam of light may impinge is the actual "twinkler," and that when one ordinarily sees a star-point of light that seems to vanish for the moment, it is due to the "resting period" of the retinal cone, and that adjoining cone must be turned into place to receive the impression, for it is a well known fact that nerve impulses are discontinuous, and that parallel nerve lines spell each other out.

This phenomenon is well exemplified with the familiar F-L Stereo card whose background consists of oblique lines running in opposite directions upon its two sides. While fixating upon the central figure we readily perceive the lines, but instead of their forming a perfect checkerboard such as should be expected we learn that sections of the direction lines will appear in some areas and that those of the other side do not show in this space, while in some nearby adjoining area the opposite condition appears so that the background appears to be made up of coarse basketry-work in which the lines are continually shifting. Thus it will be understood that field vision takes place in constantly altering areas, first with one eye and then with the other so that the composite pattern is not a true checkerboard.

This is a familiar illustration of retinal rivalry. We regret to state that this has given rise to the erroneous term "Areas of Suppression."

This definitely is not Suppression, having no relationship whatever to that factor since *Suspension* lies below the level of will power of conscious activity of one's will to cause the phenomenon or to hinder its continuance, or to overcome the interruption if it has taken place—while on the other hand *Suppression* lies above the level of consciousness and power of willing, such as we may make use of while keeping both eyes fully upon and using the Ophthalmoscope or Retinoscope, and the same time giving no heed whatever to the undesired image with one eye.

VISION

In some measure it may seem out of place here to review the complex factors of vision in its grosser sense of normal human vision, and many of its freaks. However, we can not complete our story, and carry it to its several logical conclusions without doing this. The eye undoubtedly began many million years ago as a half raindrop, or a mere blister upon a sensitive surface. The focalizing effect of rays of light gradually developed a light sense, which eventually produced a sensitiveness of heat, light, and shadow. From this beginning up to the point where physiological lenses were developed, which communicates with the low brain faculties of Molusks and other primitive life, we can gradually

trace through Geology and Biology, over the many aeons of time what is now known as eyes, and vision.

As this faculty is now known both in the animal, and the human beings it is without the slightest possible doubt the most complex, intricate, delicate, and ultra-sensitive instrument of which we are aware. Probably not all the mechanics known to our civilization, such as the electrical apparatus of great power plants, the distribution apparatus of telephone, and the almost infinite diversity of radio and wireless, is far less complex than just merely one of your eyes, or mine, in their relations between the outer world, and our brains and minds. The more we study the complexities of this visual sense with which we are able to reach out and grasp the stars, so as to comprehend their immensities, as well as the twelve thousand candle power of our own sunshine, we appreciate the delicacies of light and shade, of hue and tint, of the blushes on a maiden's cheek, all these and a thousand more things are compressed in our sense of vision.

The retina itself composed as it is, of perhaps—rods and cones, is believed to be served by ½ million to 1 million optic nerve fibers. Now a nerve fiber which serves several rods may be likened to a country telephone line serving several patrons although perhaps everyone does not use the line simultaneously. The fibers serving the macular area are now believed to serve each single cone, each nerve fiber being apparently an insulated wire which can not be short circuited by touching another naked wire, for its axone is sheathed in a tube arrangement with supporting nodal points, and immersed in an insulating liquid. The electrical system is as complex and complete as that of the American Telephone System.

Within the thickness of the retina itself we can delineate with a microscope about 10 "layers" of neurones and ganglia. The function of ganglia appears to be not unlike batteries which generate, electric currents and nerve impulses, two terms for the same thing.

NOTE: Quoting from Dr. Grover's fifth edition of "High Frequency Practice."

"Human Mechanism.—From an electro-physiological standpoint the human body is the most delicate, intricate and wonderful apparatus of which we have conception. Within its structure are contained electric generators, converters, vibrators, rheostats, condensers, insulators, collecting and dispersing electrodes. It develops electro-motive-force producing volts, amperes, couloumbs and watts. The skin presents a resistance of thousands of ohms. The body is full of primary cells connected in series and in multiple and develops continuous, alternating, sinusoidal, static, inductive and oscillatory currents. Its electrolytes contain anions and cathions. Its diathermic apparatus converts mechanical energy into heat. The body as a whole exhibits a polarity which is usually positive but may be changed to negative by surrounding objects, etc. It receives electrical charges and disperses them. It has electric circuits open and closed.

It not only possesses every device known to electrical science but many details of construction and activity which we do not understand.

"Body Currents—Man's body currents are direct and continuous only to a degree. It is likely that a large proportion of them are inductive. Counting the distance from origin to destination the rate of flow is about 120 feet per second. The reduction of rate of flow from that of the ordinary electric current is due to the many condensers and rheostats existing in the body. While body currents may flow through almost any tissue of the body it is well known that the nerves are the all-important conductors. In tracing any nerve from its origin to its termination many obstacles, such as synapses, ganglions and pathological switches, are interposed and delay the current flow.

"The human body may lose its electrical charge in a very short time, thus demonstrating the presence of electrical generators. A portion of the body may lose its charge while the remainder retains it, showing that the body contains many generators.

"Whether the chemical changes going on within the body induce electric currents or the ever-present electrons produce the chemical changes is not a settled matter with physiologists, but the electrical theory is fast becoming the accepted one.

"When a normal tissue takes on pathological change it becomes an insulator of body currents. The body currents being the main factor in nutrition it is logical that tissues deprived of these currents will take on degeneration.

"The voltage of body currents is very low, something like 5 millivolts. It would seem that if we were able to detect the obstruction to body currents in time and the deficiency be supplied from an outside force pathological changes might be averted.

"It has been demonstrated that in fatigue of animal or vegetable tissues the polarity of the currents was reversed. Even metalic substances are subject to reversal of polarity and consequent fatigue. Normal nerve will react to the cathodal closing of a direct current, but when the motor nerve supply is cut off by injury or pathological changes the polarity is changed and the nerve reacts only to anodal closing.

"Stimulation of all tissues from any source—vibration, light, heat or electricity—increases body currents. It is impossible to stimulate any tissue of the body without inducing currents in those tissues, and these induced currents have their physiological and pathological effects.

"A high-frequency current induces hyperemia without evident electrolytic action, and at the same time changes take place which increase nutrition. Whether these marvelous transformations are due to electrical, mechanical or chemical effects is not entirely clear, but it is the consensus of opinion of the leading physiologists of today that they are electrical."
NOTE: Quoting from W. Stewart Duke-Elder's "Recent Advances in Ophthalmology."

"Optic Nerve Currents.—The intimate mechanism of the retina has recently been further elucidated by the extremely interesting work of Adrian and Matthews (1927-28) on the action currents in the optic nerve. In the past it has been difficult to investigate the normal activity of sensory nerve fibers, since the electrical recording instruments which were available were not sufficiently sensitive, but recent developments in valve amplification have now made measurements of sufficient delicacy possible. Indeed, with the use of an amplifier, it is possible to record the response of a single nerve fiber in a large nerve trunk (Adrian, 1926); this opens up a new and valuable field of investigation of the sensory organs.

"For his experiments on the action of light on the eye Adrian employed the isolated eye and optic nerve of the conger eel since in this animal the nerve is comparatively long (2 cm.) and contains relatively few fibres (under 10,000). The action currents were picked up by two electrodes, and the electrical variations, recorded by a capillary electrometer and amplifier, were cast upon a moving film. In the dark the nerve is usually free from action currents, but on illuminating the retina a rapid rise of oscillations appears on the record, which shows an irregular succession of mono- or di-phasic action currents of approximately uniform size, each lasting about 0.0015 second. Immediately after illumination a latent period is constantly present, longer than the corresponding latent period in the retina itself. The maximum frequency of the variations occurs at or near the beginning of the response, declines rapidly during steady illumination, and there is a renewed outburst of impulses when the light is turned off, corresponding to the after-kick in the retinal reaction curve of Jolly. The essential result which has emerged from the investigation is that the doctrine of specific nerve energy appears to be upheld, and that, whatever the mechanism in the retina, the discharges in the optic nerve are of substantially the same type as those in other sensory or motor nerve. Moreover, the size of the action currents is not affected by the intensity of the stimulus, but the only variable appears to be their frequency. It is to be noted that the maxima in the figure do not represent a greater excursion, but a more rapid one; the apparent effect of a stronger current is due merely to the slow return of the mercury in the electrometer towards the base line after a sudden displacement, so that the rise in the record represents, not a rise in potential, but an increase in the number of the rapid changes of potential, each of equal amount, which represent the action currents in the optic nerve fibers. It thus appears that the "all-or-none" character of the response holds good. It would seem to follow that there is no qualitative differentiation, so that here, just as in the case of the retinal electrical variations, no basis appears to exist for the differentiation of the response to colours."

There was a time when we imagined retinal stimulations to be brought about by chemical activity. Some 70 obsolete theories of vision have been built upon this supposition, but it must be remembered that wherever chemical activity takes place it is always with either release or absorbtion of *heat*, for no chemical reactions can occur without this

physical manifestation, and where *quick* reactions occur there must be an almost explosive volume of heat released.

Manifestly this thought is absurd in relation to the rapid impulses which take place within the human eye, for we take in through them a series of retinal pictures of only a few thousandths of a second's duration, and these must be instantly abolished, the slate fully cleaned, and ready for the next picture. This would be chemically impossible, but if we regard the rods and cones as minute aerials of radio instruments, each almost complete in itself, we shall appreciate how quickly visual changes can occur when we compare the amplifying system and almost instantaneous reception period of our radio aerials, which receive sounds of such infinite variety, transmitting them with perfect clarity, and appreciate that they are instantly cleared in mere thousandths of seconds to receive the next tone without blurring, over-lapping, or shadow. Chemically this would be an impossibility, but with our present knowledge of minute currents which constitute all nerve transmission, and the known fact that light, either white or in primary colors, when focused upon a dissected eye *does* generate nerve currents in the stump, or the optic nerve, which is measurable with a delicate electrical galvanometer. Sunlight itself is merely a high frequency manifestation of electrical energy, and our artificial illumination of whatever nature, type, or intensity is known to be merely a lesser quanta.

Few creatures have eyes placed forwardly as in Man. The fish and the whale, the latter a mammal, are in an environment where their very existence, both with respect to safety and food, require that their eyes must be placed one on the east wall, the other upon the west. Now these "people" are "binocular" but of course they have no horopter. It is a fact that fish, as one may readily observe for themselves in an aquarium, in swimming about the tank rotate their eyes independently of each other. One eye looks back along his length while the other may be turned upward, or forward, and they have complete independence of movement. It follows of course, that two wholly unlike pictures are received in a censorium of his brain, which must be given independent heed, for there is of course no such thing as triangulation for distance. Certain types of fish, serpents, birds and mammals have such a sufficiently forward placement of eyes that there is a limited horopter. Where this horopter has developed to a fairly large overlapping amount a new form-sense *may* begin to take place, although it does not always do so. When this form-sense has arrived at a higher level of intelligent action, the sensation of triangulation for distance, and stereopsis may have taken place. Although we have plenty of data at hand it shows that it does not always do so.

It is almost beyond comprehension how an eye, regarded merely as a camera, a device for focalizing a piece of the outside world upon its background, and sensing this upside down picture as being right side up "out there," can take such pictures and reassemble them into an understandable composite. Analysing our human horopter, the horizontal visual field of the right eye extends 110 degrees, and past the nose some

30 to 35 degrees, a total of perhaps 150 degrees. The visual field of the left eye with the same angle of vision gives us in the central field an over-lapping frontal arc of 60 to 70 degrees. Now these central degree areas are common to both eyes, yet we have learned to assemble these fields which are not common to the overlapped portion of the picture and do not leave us with any sense of reduced outside field perception. With both pictures inverted the central area reassembled, and by calculation their distances brought into factual relations merely by experience, trial, and error, we are prepared to understand, in some measure, this visual function. But the moment we walk to our mirror to shave, or comb our hair we find that our left hand has gone over on the right side of our body, so we must reinterpret positions and movements again. But explain if you will, that while the mirror has *reversed* the two in our mind from left to right, it has not also *inverted* them from top to bottom at the same time! There may be an answer to this although the writer can not give it, unless it *may* be due to the mere acts of experience, knowing the floor must stay down, and the ceiling up at the same instant when his right hand is functioning as though he were left handed. But how shall we picture this reassembled topsy turvey world upon the background of our mind. It reads like a veritable Alice in Wonderland, yet it is a living experience of right to leftism, without topsy-turveyism.

Now if you can picture our primitive human being as having but one eye in the middle of his forehead, as the Cyclopian eye, we might understand some of these anomalous conditions, but with two eyes working sometimes in team work, and sometimes against each other, the picture becomes highly complex, although in order to point the eyes to the right and left, for careful delineation of well focalized images, they must turn from side to side harmoniously, and in perfect alignment, since if they were two pieces of artillery which must be discharged at the same instant of time, and hit the same point of a distant target, their angling must be of very high order.

We have a reasonable large lateral movement of the eyeballs of from 25 to 40 degrees. Now these lateral movements are under the control of a gun crew, which have specific instructions, the penalty of whose failure might be fatal to the individual. Their performance extends over tens of thousands of pointings in one day, and their work must be within very small toleration of accuracy. In the act of reading, the lines of type are small, the differences in letters is slight, and meanings are of considerable variance, and yet the eyes must be "gunned" so that there is no doubling, and both must arrive at the same point of fixation in absolute precision. From a large number of experiments carried out by Judd, Dodge, Cobb, Tinker, Miles, and Shen it is known that the number of fixations per line of type, in common reading, is from 10 to 20, or more. Now in reading we have the lateral movements over one set of gunners, and another gunner who must occupy a superior position of command, in which some degree of convergence takes place so that the sights as they are converged, and move laterally to degrees of convergence, whether to

an extreme point, near point, a middle distance, a far distance, or to what we call "infinity," must have those small differences of convergence combined with the lateral movements by which we can discriminate "how far" away things are.

Now many handicaps may intervene both in the motor mechanism, which is under control of that area in the brain forward of the Fissure of Rolando, and in close proximity to that convolution which controls the arms, hands and fingers.

It perhaps is not out of place here to give consideration, and to speculate upon the manners of the convergent act at the reading distance. It has been amply demonstrated that we have a dominancy of eyes, just as we have of hands, arms, legs, and feet. While there are such individuals as are termed ambidexterous, those who are equally skilled in the use of both hands, they are so rare that we scarcely meet a true one in a whole life time. In precisely this way we rarely find a person with equal eye dominance. The "boss eye" does the main act of pointing at the object of fixation, and the other eye follows up to it.

Generally the dominant eye is the one having the higher visual acuity, although this is not to be relied upon. Let us suppose a case where both eyes are normally and equally acute, and the eye balances fall within tolerable relations. If this person is engaged in reading his eyes must follow along the lines of type from left to right, at a speed which is agreeable to his comprehension of the text. We do not spell out by individual letters but seize upon the whole word or a complete phrase. If the text of the type is easily grasped, one reads with a lesser number of fixations per line, than he does if the subject material is difficult, or if it is in poetry where emphasis must be given to words in rythmic order, and punctuation followed carefully. Reading a language with which one is not fully conversant, demands a far greater number of fixations per line, than the same subject in one's native tongue. Material containing figures, characters, algebraic equations, and the like require a large number of fixations per line, spaced closely together. Miles and Shen have gone deeply into this subject.

Now it is conceivable that these 5, 10, or 40 fixation points along one line of type may take place in one of three—and only three—possible ways: (a) the locked angle of convergence may be considered as a simple point upon the line of type, this point hopping along from one position to the next, as we pick up and interpret the words. We might compare this to clasping our two hands together with our fingers in a tightly locked position, and extending the index fingers to the various points of regard so that both arms must move rigidly together. (b) Another method may be considered as a walk-step, in which one eye steps forward to its fixation point in the line of type, the eye dwelling for a sufficient period of time to interpret upon the retina, and transmit to the mind a certain concept of the text, and while this was going on, or at a subsequent instance of time the following eye, having completed its previ-

ous task, steps over the advanced eye reaching out into a new portion of the line of type, and begins its interpretation. This would be not unlike the act of walking, where one foot steps ahead of the other, first the right, then the left. A third method, (c) could consist of a sort of ratch-step, or shuffle-step, activity of the eyes in which the first eye moved forward to its point of fixation, followed soon after by the second eye sliding up to the same point of regard, and as soon as sufficient interpretation is completed by the pair the first eye to glide forward again, soon to be followed by the other shuffling up to it. No one yet knows which of these three types of eye movements actually takes place. It is possible, of course, that one individual has one personal or typical method, while another may function in another way. It is probably a demonstrable fact that neither eye may be said to "see" during that brief interval of time during which the muscles are actually rotating the eye from one position to the next. This brief interval of time is calculated to be from 1/10 to 1/1000 of a second. If the eye were actually transmitting a picture to the mind, throughout this period of moving forward from one point to the next it would be expected to produce a blur, like looking from a car window of a railway train.

The eye may be considered as perceiving, and the mind as interpreting, merely during the "dwells," which intervals are in the order of hundredths of a second. Thus we make up on our mental background a piece-meal picture of reading material, or of work, which must be a sort of jig-saw puzzle, consisting of blind spells, and things to be seen. Now if the eyes are considered as moving in the A manner, and both are "blind" at the same instant, this is one type of vision for our attention. If, on the other hand, eye movements are of either the B or C type, then the blind instants do not occur simultaneously. There is a tremendous amount of misunderstanding due to our lack of definite knowledge, as to *how* this act of convergence, either simple or highly complex, actually takes place. If we treat it lightly, each eye may be said to come to rest in whatever position the normal tension of the two neuro-muscular balances of eyes dictate, and the streak will be either right, left, or on-line. Valuable as this test is in certain places, it does not, however, answer the full demands of definite knowledge upon the subject, for it is merely the characteristic way the entire visual function may assume when it is standing "at rest," like soldiers in the ranks awaiting a further word of command, for they are merely *positioned* for action. It may be as characteristic for an individual to exhibit an esophoria, or exophoria of 2 or several diopters in this position of expectancy. At the usual reading distance we have empirically set down the 6 diopters exophoric position as an "expected," whatever the mathematical calculations may be from which this is derived. We must again consider that this is the characteristic individual, wholly imaginary, resting, or position of expectancy, of the soldier *awaiting* command, but not in actual march. Again, there may be a characteristic normal deviation from this "expected" position corresponding to our eso, exo, or on-line, without exhibiting any anomaly

whatever due to muscular tonus. In either the distance test, or this near test, of "rested positions" we have practically no data whatever, as to the manner and degree of functioning of the eyes while performing actual work. It is a pure presumption to adopt either of these units, and to declare therefrom that there is a lag of convergence behind accommodation of any stated or specific amount, and to deduce from this vague X quantity, that it is either physiological or pathological. We are attempting to build up from several unknown or unsound factors a platform from which to make conclusions.

Reverting now to either the 2, 3, or 4 order of Intermittent Vision we can appreciate that, if there are conditions which induce a break in the continuity of the visual act of either one or both eyes, when they are in use, either for near or at distance that the judgment of the individual is much handicapped, or completely without value of triangulation, whereby to a great extent distance judgment is based.

We can, of course, judge the distance of objects by two methods. We know from experience the size of a man, or a ship based upon the size of his retinal image, and even a one-eyed person can estimate with fair accuracy, the distance of such an object by his memory comparison. Now by the act of triangulation, and the amount which our experience finds necessary to converge the eyes to that point where possible visual axes meet, we largely base our judgment of distance. The combination of the two by those whose binocular vision is fairly normal allows a very practical estimate of the distance of any object. However, if one eye has an interruption, his triangulation will be defective to a degree proportional to the period of Suspenopsia, and consequently his visual judgment is injured. It is highly important that both eyes function uninterruptedly so that the mind may see with speed and precision.

Now one might say that it is "natural" to see with both visual organs at the same time, and without interruption. One might also say that it is "natural" for a fish, or a cow to see with both visual organs at the same time without interruption. Here we have to ask ourselves for a more specific definition of the word "natural," since the fish and the cow are so constituted that they may look out only sidewise, and cannot see the same object with both eyes simultaneously in a position which gives the stereoscopic sense. Either these creatures must have two minds, and two independently working brains with two judgments, or they see from alternate sides of each brain, but not from both simultaneously. For the environment these creatures inhabit their vision is adequate to their needs, but a human being who has inherited similar characteristics is under a definite handicap. We have said that vision is a highly complex faculty, and here wish to reiterate the statement that it is even more than this. Those who have read Biology, and especially that portion of it which is concerned with the breeding of even such simple things as flowers, are well aware that when a mass of seed is sown into the soil, and the plants have come to maturity that some of them exhibit parentage of ancient ancestors, that many of them will be closely associated in appear-

ance with that of immediate parents, with here and there one which shows an improvement or advanced status. Should we select seeds from these improved varieties, replant them, and raise another generation, there will again be many throw-backs into an ancient lineage. Should we select seeds for further improved varieties, and carry out the culture over an indefinite number of generations, many of the descendents will carry the same, or similar faults, as those of the most ancient prototype.

Now the word "faults" may be considered in many lights with respect to flowers. We may take as a basis color, size, or height, or foliage, or fiber, or procreation, based upon any one or several of these characters where one plant may be said to be an improvement over its ancestors in one way, while it is inferior in another. It differs wholly upon what character we are investigating. This holds perfectly true with mankind, in his relations to savage life, and earlier arboreal life, a primate life, and his far distant mammalian ancestry.

We have inherited vision, but vision is a many phase function. It has come down to us solidly. It does not remain with us solidly. We do not transmit it solidly. Things we may do with our eyes, our parents may have done. On the other hand, our parents may have done things with their eyes, which *we* do not do, although perhaps we could do them if we were taught how. Merely because our parents were scholarly we may not have acquired scholarship, for these things are largely a matter of education. In fact eye sight IS education. It is how we use this primary function to its very fullest capacity, that determines our status in life. We act and live chiefly as we see and interpret things about us.

It is not even passing strange that we may revert, and DO revert, in such particulars as monoptralcy, or one-sided perception of the visual sense although we are fundamentally "binocular," for two-eyedness is not necessarily double-mindedness. Now if the mind is sufficiently alert to receive, and to assimilate two similar pictures of the "out there," the person is truly binoptral as well as binocular. But, if per chance, he only gives "heed" to one picture at a time, he would be exhibiting a characteristic "throw back" toward a more primitive state. Now those things which we do without effort are easily accomplished, but if for some one slight reason an extra effort must be made to overcome even a small handicap, there remains that tendency to slight this function, or minimize its meaning. Such a handicap may, for instance, be a difference in the amount of astigmatism of the eyes, a very slight difference in the size of the retinal images, as in Eiseconia, to a slight imbalance, or from some of those unaccountable Amblyopias. There are doubtless many causes producing even the small handicap, or tendency there to, which could well be the source of an interruption of vision.

We are often asked what is the cause of Suspenopsia, and how are we going to "cure" it? Both are obscure. We may consider vision as a habit, but we should construe it as a great many habits. We seek to improve the manner of habit in sight just as we do many other demeanors,

in other fields of life. If there are physical handicaps, Optometrists seek to remedy them with suitable lenses, should these be required, but it also concerns itself with training the eyes, the visual faculties, and the mind of the patient for the highest possible attainment in this function. First remove all handicaps, then adopt and develop that portion of Myology treatments which will bring about true coordination.

Let me qualify a term. We have rather inadvisably adopted the word Orthoptics as a blanket term for these many manners of treating visual function for improved conditions. Even a slight analysis of the term Orthoptics indicates that it refers solely to the Optical, or light focusing function of sight, but there is more to this subject than merely this half of it, for we are also concerned with the *Phoric* state, in fact, in much of our treatment work the *Optic* does not need any attention whatever, while the *phoric* condition requires our entire effort. Hence in such cases it is not correctly styled Orthoptics but Orthophorics.

In This Paper we shall consider this subject in the double term, Orthoptics-Orthophorics, with emphasis upon that portion which requires most effort. Perhaps I may illustrate this by a case of a child whose visual acuity is raised to 100% O.U. with a low plus power, but who exhibits an esophoria of 16 Prisopters. Manifestly he requires no ortho*optic* attention whatever, the whole work being concentrated upon ortho*phoric*, and a reference to such a type of case is this, as ortho*optics* is highly ambigious.

Perhaps one of the first questions a parent or a patient will ask us is, "What is the cause, Doctor, of this condition?" The first question the practitioner will ask of himself should immediately be, "is this a case of Ambloypia, dullness or bluntness of sight of a type which resists raising to a reasonable visual acuity status with the correcting lenses, or is it a true Phoric case?" Now, of course, a high astigmia or Hyperopia may be the fundamental cause of the low vision. Correcting lenses sometimes will bring acuity well toward normal, either immediately or within a reasonable period. The eye which *has* never been able to see, cannot be expected to at once correctly interpret the shape of an image, such for instance, as an astigmatism of 5 diopters would produce on the retina. A Hyperopia of a large amount has *always* produced such a blur on the ground-work of the eye, that it was beyond its resources to correct. It would not be at all strange, if a corrected picture by the proper lenses still left an impression, which was of low value until such time as "trial, and error, and adaptation" brought about a clear mental understanding. A high Myopia, however, or Myopic astigmatism, does not necessarily induce an Ambloypic condition, because it is well within the range of the subject to hold their work closely enough to obtain a fair retinal picture, and these of course, the mind has been able to make full use of. Hence there is a differentiation due to the general type of Optical errors whether within the Hyperopic or Myopic range, and the Amblyopia may be due only to Optical differences.

The action which takes place in the brain is often compared to that of a vast telephone exchange where an enormous number of messages are being constantly received and dispatched in every direction, to many organs, glands, muscles, or joints, and where O-kays are constantly coming back that these multitudinous orders have been received, acted upon, and certain results attained. The investigations now being carried on at Harvard Medical College seem to indicate that many wave lengths, and an unknown number of frequencies of electric current passes along the axones.

"In another sense, we can better appreciate what these frequencies do if we make another comparison, that of an enormous freight yard where long trains are arriving, are disassembled, some cars being placed upon this siding, others upon that, where these new combinations are to again be coupled together for another series of trains destined to carry their burden into distant localities. Some of these cars will carry similar contents, where they are now considered as nerve-frequencies, although they had originated from widely distant points.

"Sensory impulses are centripetal, or inward, while motor impulses, either to muscles, bones, or organs, travel outwardly, but nerve currents never travel in the reverse directions along an axone. Thus the collection of nerve impulses in the brain is called *integration*, which is more than a mere addition process; the separate impulses are put together in such a way that their relations closely resemble those along the originally stimulated nerve. Thus integration is the *systematic assembling* and marshalling of all the impulses which reach the brain at a given moment. The other important feature of the brain's work is the proper *distribution* of motor impulses, this being *co-ordination*, for in order to perform any complex response correctly, the brain must start a number of impulses along different motor paths at the same time, and each impulse must be regulated to the proper intensity, and must continue just so long. Co-ordination involves all this, for it is vastly more than mere distribution, it is *systematic* distribution. A familiar illustration of such co-ordination is that of a pianist or typist.

"One generally thinks of his movements and voluntary actions as being performed by his muscles, but as a matter of fact the muscles and other organs are mere agents, under control of brain centers, for co-ordination is a brain process, not a muscular process, a method of sending the *right* motor impulses out to the right places at the right time, and not for too long a time either. Consider the centripetal impulses of the ball player who visualises his ball, its size, its constant approach, his co-ordination of visual faculties until that split second when it may be seized from the air by centrifugal motor impulses. Watch him again as he winds up, measures the distance and direction of his catcher, then hurls the ball with force and curve enough to fulfil requirements, yet with none too much of any factor. Two processes of integration and co-ordination must work together, for all responses to stimuli must, except in the very simplest cases, involve them both. Most of our actions

depend upon a great number of changing stimuli, and are accomplished by a long series of complicated movements, for we must learn to fit responses to the situation, the integration of all the stimuli and co-ordination of all motor activities. The system of combination and co-ordination is called *adjustment*, which must be constantly cared for because of the continually changing conditions.

"The nervous system serves as a network of pathways over which nerve impulses pass from receptor organs through the centers of muscles and glands. The nerve activity starts with *stimulation* of a receptor which produces an *impulse* in the sensory neurons which travel along the sensory paths to the sensory centers in the cord and brain. In the sensory centers these impulses are integrated and pass over motor nerves to motor centers where coordinated motor impulses are set up in the motor nerves. Thus the *motor impulse* travels along motor pathways to appropriate muscles or glands, and discharges its energy into them, thus constituting a *response*.

"The nerve impulse varies in intensity, quality and frequency, these characteristics being determined in the first place by the nature of the stimuli and receptors. There are certain properties of the nerve substance which determines what the impulse shall be, over and above the stamp which it receives from the stimulus. These properties are *excitation, conduction, retention, fatigue, collection*, and distribution. The activity of the nervous system proceeds through a circuit or arc from receptor to effector, each arc being composed of three sections: *sensory, central*, and *motor*. Corresponding to these are three phases of activity: *stimulation, adjustment*, and *response*. The adjustment process is the most important of all for it includes *integration* of sensory impulses and *coordination* of motor impulses. Integration and co-ordination work together and tend to make our responses appropriate to the total situation at any given time. *Adjustment* is the most significant fact of life." (Warren, Elements of Human Psychology.)

These facts are well brought out by Keith Lucas, p. 93 wherein he reviews in some detail the mechanism of reciprocal innervation. He says: "We set out to inquire whether the elementary phenomena of conduction of tissues could give a satisfactory basis for the understanding of conduction in the reflex arc. We have seen that the two of the most important phenomena of reflex conduction, namely summation and inhibition, can be reproduced in isolated nerve-muscle preparation, and that in this case they depend upon a very simple mechanism.

"It is known that nerves do not all transmit neuricity waves with equal facility, or speed, or frequencies; but that their rates of transmission vary with the structures they serve.

"The two processes of decrement and increase depend simply upon the normal recovery phenomenon in nerve, and in the action of a region of decrement in extinguishing impulses of small intensity.

"We believe that regions of decrement are normally present in the junctional areas of the central nervous system, and therefore we have in the reflex arc all the conditions necessary for the production of inhibition and summation.

"In fact if we consider the complications which are introduced when the impulse has to pass several relays of conductors, the most varied possibilities are opened without introducing any assumptions which have not been proved in the case of peripheral conduction."

In Intermittency of Vision, it is now reasonable to believe that "fading" is a visual manifestation of the summation of stimuli, of its reduced effect, and also of the cessation of visible perception of a macular image which is positively present upon the retina, and that this image has not of itself changed in intensity.

We are not here speaking of cause as much as we are studying how these results may take place from an unvarying intensity of stimulus.

There seems no possible doubt that Amblyopia is founded upon some obscure condition far behind the retina, and residing, of course, in the brain censorium. We shall speak of this at another time, where we attempt to answer a portion of the question as to the possible, or probable cause of this eye deficiency. We have compared the eye to two guns trained upon a distant target. If for some cause, one of the guns is not pointed *at* the target, and cannot be properly brought into the direct range, its bullet would be sent far a-field, and pictures taken by the eye, where one of them referred to some useless point of view, would cause confusion. Hence it is logical to expect that the mind would soon learn to ignore every picture from this wrongly directed eye. This, of course, would be an Amblyopia which is commonly understood to be due to disuse. Now it is entirely possible that the retinal picture from this eye is sufficiently sharp, clear, and correct enough for use by the mind, or that some lens correction would make it of practical utility, but for the fact that it is so wrongly pointed that its picture causes confusion and hence is unreliable. This is not by any means an unusual type of case, and we find that when its mate is covered the mind can use the retinal picture from this inefficient eye in a practicable manner. Seating the patient in the chair, and directing his attention to the large bright fixation spot of light across the room we place before one eye a red, and before the other eye a green filter. Instruct him to tell us which light he sees. He of course will describe the light as it appears through the filter before his dominant eye, but if we cover this one for a moment he will be able to see the other color of light, with the mis-directed eye. We desire that he should see both lights simultaneously, even though they appear far apart, but the instant that both eyes are uncovered he visualises only with his dominant eye again. Right at this point we wish once more to bring forward the strongest possible emphasis, first, that this is a case of true BIN-ocular vision, for both eyes are perfectly capable of focalizing the colored spots of light upon their retinas, hence, their vision is correctly styled "binocu-

lar" although *both* these pictures do not reach the mind, one of them being estopped somewhere in transit so that visual sensation is Monoptral, for there is a vast difference between binocular and binoptral vision.

It is often difficult to COMPEL the subject to actually *perceive* both lights simultaneously. He may exert his utmost will power, after having looked with first one and then the other eye to see them both at the same instant. Now it is not important whether colored filters are placed before the eyes, or whether first one white light and then the other is observed, or whether a fraction of the test chart letters are viewed, or any other object. It does not matter how *forcefully* the patient determines to retain both retinal impressions, he may WILL it with all his mental energy, and yet one picture or the other fails to reach his mind, it being *below* the level of his will power. One cannot reach down to that level of dual control of both pictures so as to hold them. Intermittency, or Intermittent Visual Perception, (Suspenopsia) is below and beyond the force of will power.

Now suppression is something he can *will* to take place, because it is *above* the range of willing, wishing, and requiring, for the marksmen, the engraver, the watch maker, the microscopist, as well as the Optometrist, who has trained himself to use the Ophthalmoscope, the skiascope, and the Keratometer, with both eyes normally open, while ignoring the picture of the unused eye. One act is involuntary, since suppression is above the level of will power. It seems as though these two terms should now be properly clarified in the minds of the Optometrists, since both the terms and the phenomena are fundamentally unalike, and the conditions they describe are in no way similar.

SUSPENOPSIA

We have a number of stereoscopic cards from different authors where the objects for his right eye and left are similar but unlike—such for instance as the F-L card. On one of these cards there is a cross-hatch background where the lines run obliquely and behind the other letter they run at an opposite oblique. Now the normal subject will fuse F-L into E, but at the same time he will describe the background not as we would perhaps expect, a double fused grid, but will see alternate patches of these markings in a broken-up Mosaic pattern. We would, of course, expect that if the E is a fused letter of *Macular* vision that Field would also be equally fused. The result is somewhat startling because these oblique lines do not make a true grid, they keep coming and going in patches, here and there in spite of all our effort to fuse this surrounding space, for it is quite evident that we do not perceive all over both letters simultaneously, or that it seems more likely the retinal pictures are not continuously maintained upon the mental background. We are playing with two types of vision, Macular in which a picture is transmitted to the Calcarine fissure of the Cunius, or hind brain, and Paratiel, which reflects field vision. Now from a purely biological standpoint it is quite

evident that field vision is the old fundamental and basic method of "seeing" for through this factor of sight a wide field is observed. The movement of objects at almost any position is instantly detected and relative direction, size, color, and other characteristics are quickly given attention.

Interspersing this retinal field, composed chiefly of rods, are a few cones. As we approach the macular field the cones increase in relative number until central vision is reached, and only cones are found. Now each cone, whether in the field of macula, has its own single optic neuron which is carried back through the commissure to the optic thalmous. The rods are apparently not thus singly connected, but several of them are served by one Axone which extends, among the rods, and innervating the parietal regions of both brains. Virtually, therefore, each eye is a duplex optical apparatus with two quite distinct types of vision: Macula to Cuneus, and field to parietal.

Knowing these facts we can not appreciate why, in making check tests for the phorias with a maddox light and ribbons, the patient remarks that they see both ends of the ribbon, but that the center seems to vanish, or that while the center remains in view, both ends seems to fade and come back. We find it necessary to differentiate sharply between field and macular vision in the detection and handling of intermittency, since this anomaly may be of the central sight or of field vision. As previously explained, primitive vision is entirely field vision, while macular vision is a development which has perhaps reached some height among primates, but to higher efficiency in man. Certain it is that no creatures of the lower orders whose eyes have not a rather wide latitude of convergence would be able to fixate simultaneously with maculae, if they possess them. In fact, this act is such a recent acquisition that it is none too well founded in man, and is so easily disturbed that we find many "throw-backs" among our patients. It has never yet been shown by histologists, that an amblyopic eye itself was in any sense whatever, organically abnormal or defective.

Amblyopia seems without the slightest doubt to be a defect of central vision, for a field vision amblyope is as sensitive to movement, to color, and to latitude, as that of the other eye. Perception is dulled in the central field, but if it has perfectly normal and healthy cones, there is no organic reason for failing to see with them, and the slip must lie somewhere between the optic thalmous and the calcarine. It is undoubtedly due either to an arrested development in this portion of the brain, or to something which was injured at or after birth.

From the undoubted fact that many intermitters are able to perceive the *ends* of the maddox ribbon, but seem to lose its *center*, is proof enough that there is such a thing as central intermittency. If this were a work upon the treatment of cases for an orthoptic/orthophorics, we would devote considerable space here to various methods for the development of macular vision, and bear heavily upon the well known fact that fiield vision is the first thing to be grasped in resurrecting the vision

of an amblyope, for when we can create upon the censorium of his brain a picture of the moving ribbons of light from the maddox rod by twisting rapidly back and forth in the instrument, so that he sees the two lines of light move. In fact, frequently by doing this with both maddox rods crossed at oblique angles, and while they are both kept constantly in motion, it is actually the first time that such a person has really perceived with both eyes simultaneously, and is often quite a long time before they can retain both pictures when they are stopped. Beginning from this primitive foundation, we gradually work forward to a perception by macular vision, and finally develop a binoptral central vision. We must be constantly alert, however, to correct such visual defects, which even though slight, may in any way handicap this eye in a sharply defined retinal picture, and also often resort to rather large prisms to deflect the picture into a range which can be grasped without effort. The accommodation is usually very defective in an eye of this type, and needs a bifocal whose segment is sufficiently strong to give a focal image without *any* ciliary effort.

It is our common knowledge that field vision when directed toward the big *E* of the chart, is usually just about capable of delineating it when its size represents from 2 to 5% V.A. It will be logical at least to expect, that this is perhaps because the few widely scattered retinal cones in the rod-field eventually reach the "reading area" in the calcarine fissure. It is to be noted also, that an amblyopic eye, when its central area is directed toward this same sized letter, has practically the same V.A. The optometrist should try this experiment upon both of his own eyes, and those of many patients, so as to get the full import of this fundamental fact. It is a common saying among us that the central seeing spot is the "only educated part" of an eye. We know that when one looks directly at the sun, or some other intensely bright light, the eyes are glare blinded by it, since it forms a central scotoma, which is a slight temporary injury of the macula. Carefully cover one of your own eyes, take a position where you can look directly at the sun, or some other intensely bright light, being *exceedingly careful* not to allow your eye to fall directly upon it, but at the same point a few degrees away, upon some side fixation point on the horizon; maintain this fixation position with one eye for a full minute, then close your eyes and go into a darkened room, to observe the "after effects." You will scarcely be able to get the sun's disc in view with field "glare." Now repeat the experiment, but look directly AT the sun for merely one second of time, after which close your eyes, and go into the dark room again. This time you will "see" the sun for several minutes. Macular vision becomes temporarily blinded, whereas the few scattered cones in the field are insufficient to take on this scotomatous condition.

Complaints and comebacks reach us in varied forms, sometimes due to actual faults of lenses, or their adjustment, while often enough errors on our own part in refraction are the basis. It matters not how much

experience one has acquired, how infallible he considers his own judgment, how cock-sure his techniques, what impressiveness of showmanship he may have acquired, it is impossible for the best, or the worst of us, to avoid these headachy moments of self-communion when we ask if we are wholly above board with ourselves. For cases DO come back with the complaint that: "Doctor, there is something wrong. I am not getting the comfort I need." We go carefully and minutely over every test, and check test in the curriculum. We analyze and balance equations. We question the patient far beyond routine. We re-examine them under fatigue conditions. We give them tentative prescriptions, and hold them for frequent checks, but there remains that evasive "something." Now these people very likely exhibit what the world considers "normal binocular vision." There may be either high or low imbalance, which we have taken care of either prismatically, or by some of the various exercise treatments, all without the results we desire.

It is sometimes said among practitioners that they are satisfied if 90% of their patients do not complain, and let the kicking 10% go elsewhere. Now a 10% leak will sink the biggest of ships in a very short time, and an architect or builder who would admit errors like this, or in fact any other amount, would himself shortly fail. There is no reason for an optometrist, if he is as conscientious and honest with himself as he wishes others to believe him, to allow "leaks" in doing his professional work. We have mentioned 10% as a frequent statement, but if we qualify it to 1%, or the tenth of 1%, there is still unsatisfactory work which can and should be improved. Optometry has been constantly improving itself by studies of many factors, and faculties hitherto unsensed, but when we come to appreciate the facts of their existence we were amazed that we made such progress as we did. I do not wish in this paper to preach a sermon, but I do wish to emphasize the fact that mankind, "does not know it all yet," nor do the best of we eye specialists understand much of this highly complex subject.

Demands upon human vision, has necessarily undergone great changes within historic times, due to the advance of manufacture, literature, and the arts. Burdens we are laying upon our eyes were unknown to our grandsires. We need only go back a meager ten or twenty generations, a mere speck in the point of time, to land in bark canoes upon a savage coast. Now these earlier denizens of our forests and fields, followed the chase and boat, for fishing and hunting furnished their sustenance and clothing, their education in the sciences and arts being practically nil. Accommodation or convergence, the phorias, the trophias, the hyperopias, and astigmias, if, per chance, they existed, were of no consequence. The burdens, we, today, are laying upon ourselves in every department of life, particularly upon vision, are wholly new.

There being no lamp of learning to which we can refer, we must carve out our own destiny from our own experiences, hence these visual anominies, particularly the intermittency of vision, is a subject we can-

not glean from written books, only from the book of nature, and of this book either a page or a whole chapter is quite likely to seat itself in our ophthalmic chair at any hour of the day. Now these are chapters of lore, in a mysterious language whose very terms, expressions, and meanings we find difficult enough to translate into our own jargon, but are the methods of expression which our patients use in their endeavor to explain to us their difficulties, while we gropingly seek to get the gist of their meaning.

One fairly illustrative case of my own (once cited in an early publication), was that of a young lady in a shoe shop. She was a machine operator whose work consisted merely of sewing a straight seam upon the shoe. She first came to me for eye care, complaining of the usual headache and strain, which was apparently correctable by weak plus lenses. Under routine examination she exhibited no imbalance of consequence, and was given a correction which seemed adequate, but she came back a few days later, almost in tears, saying she had lost her job on account of her eyes. When questioned she said it was because her seams were crooked, being unable to sew a straight seam, for they all had a rail fence appearance, spoiling the material. I quickly checked over her case, and could not find that there was any gross error in the lens powers, but on rechecking the balance with the usual maddox method, she said that the streak vanished. I immediately shifted the rod to the other eye, and again she commented that the streak vanished. She also stated that sometimes the light went out instead of the streak. Further experiment showed under the various check tests previously described that first one streak, and then the other vanished, or that if a vertical diplopia was produced, first the upper light and then the lower light would vanish. Watch in hand I timed these periods, finding that the *on* and *off* times were from 2 to 5 seconds. Now at that time this was a new problem to me and my optometric education opened no avenue of explanation. In addition a review in all the literature available disclosed nothing. It looked like a new star in the optometric firmament. Her work as a seamstress required that she keep the direction of her needle with the direction of her seam perfectly straight. This we normally do with a fixed convergence, for the needle position advances in a direction corresponding to the converged fixation line. What happened in this case was that she fixated and directed her seam with the right eye for a few seconds, while the other eye saw it at the next moment, yet wholly without her sensing it her vision switched, the right one suspending while the left one took up the function of directing the seam. Every few seconds the eyes "changed shifts," the result being the rail fence seam which her employer complained about.

This is a typical case which is duplicated in every shop, school, store, office, and factory in the land. Periods of intermittency vary from a fraction of a second to many seconds, a half minute, a minute, and more. Many times, in fact, quite frequently, the subject is wholly unaware that they are seeing with one eye for a time, although when this test is made, and something of its meaning is explained to them we are surprised with

their answers and comments, upon asking of them if they ever *sensed* that they were temoprarily seeing with but one eye. When this fact is brought to their attention they will frequently tell us in words of their own, but in terms which *we* have hitherto failed to interpret, that there was some sort of difficulty which they could not explain, but which now had a meaning. Now we optometrists in our routine examination can go back over our twenty-one point examination, measure and remeasure our lenses, question and requestion the patient, attempting to type or retype these people, all without results. School tests, highway tests, hospital tests, and all forms of commercial examinations, fundamentally fail to disclose more than so-called "binocular vision," whereas the patient may have so-called binocularity, but be handicapped by monoptralcy by these interruptions of various periods. We could fill pages of a large book with cases and methods of test, of handling, and procedures, but it seems sufficient to discuss the basic factors, and leave the others to build up their own case histories.

These two cases, which I will here briefly review, have such a similarity that they may to some extent be compressed into the same descriptive paragraphs. The first is that of a middle aged lady, who had only come to consult me late in her bifocal days and whose eyes were very exotropic. This patient had no binocular fixation. At *will* she could say to herself: "I will look with my right eye, or, I will look with my left eye." Now while she was looking either at distance, or prox, whatever was within the field of vision the other eye was unseen, unsensed, and unknown. She had easy, quick, and full volitional control with which either eye could be brought into service. While it is possible that sufficiently high prisms could have been used to bring both visual axes to the same central point, it would have been impracticable to use them. Experimentally we brought this about in the phoro-optometer, but the sensation was so unusual as to be unbearable. The other case was that of an early presbyopic draughtsman having some 10 or 15 prisopters of exophoria, but who also had volitional control sufficient to command the use of either eye freely at will, but was unable to converge. It was probable that heavy prisms might have been incorporated, had he been willing to use them, and it was also within expectations that orthophoric treatment might have overcome much, or all, of his divergency, but he could not be induced to take the time necessary and put the work into it, being satisfied with this monstrous difficulty.

With any of the several test methods described elsewhere, was it not possible for either of these people to sense binoptrally until considerable prism powers were added, and even then one object or the other would vanish unless it were given an attention-commanding *movement*, but as soon as this was stopped they both reverted to monoptralcy, although there was no possible doubt but that the object of regard was sharply focussed upon their maculae, and that true "binocularity" was indubitable. Monocularity and binocularity refers specifically to retinization while monoptralcy and binoptralcy describes mental perception.

The draughtsman described his habit of using one eye while the other was resting, having acquired alternate volitional control of them. In his case also, the divergent eye, or that portion of his brain which was stimulated by it, was mentally blind.

Another, and quite typical case, is that of a boy who first came when nine years of age, having hyperopia of approximately two diopters, and fifteen of esophoria. There was an apparent hyperphoria, the amount of which we could not determine because of intermittency. Had this been "suppression," the case would have been able to suppress perception of his seeing eye, at least under my control procedure, but even with his uncorrected hyperopia he might have still maintained binoptralcy, were it not for the high esophoria. The phoric eye refused absolutely to see, while the fixating eye was uncovered, it being a case of absolute suspension. The moment the dominant eye was covered, however, this non-dominant eye would come to the fore, and was capable of functioning. When the hyperopic correction in combination with the 15 diopters of prism power was placed before the eyes, and the 5-inch fixation disc was used in connection with the red and green filters before the eyes, only the dominant eye could or would see its color. The instant, however, the dominant eye was covered, the non-dominant would function and see *its* color correctly. The case was so intractable that it took a number of sessions before it was even possible to make both eyes function together, and both see colors coincidentally. There was such a powerful dominance that it took time, and much work to break through this cloud of mental delinqnency, and improve the retinal and brain lack of pattern so that the mind could sense and react to both at once.

This is a typical fourth order of suspenopsia, which was beyond intermittency, but not volitional suppression, which it would be wrong to style as "intermittent," because there never was an instant when the sensation of simultaneous perception rose to consciousness. This case turned out successfully after a considerable period of treatment, but probably for the first time in his young life he had ever sensed two pictures from his retinal images at the same time, came after the third or fourth treatment, and was only brought about when we used the large fixation light, and both maddox rods with a red and green filter before the eyes. Individually he would see a broad and extensive vertical band of light with his dominant eye, but an equally large green light was not seen with the non-dominant eye until we kept both maddox rods *moving* from side to side. After a time the movement stimulated perception so that it rose to his level of consciousness, and he could then reply that both lights moved. For a time we found it unnecessary to move the bar before the dominant eye, but by so moving the one before his non-dominant eye he was brought to reply that one of the bars was still there, and the other "seemed" to move. When we had attained this victory both filters were removed, leaving only the two vertical bars of light which he now described as two white bars of light, one of them being in motion. The instant, however, the movement of this bar before the

non-dominant eye ceased he would see only the dominant eye's picture. Now there is no doubt whatever that at this stage it was a true "binocular" case, yet it was still "monoptral" because only one message carried through to the mind. The next process of treatment was the reduction of the size of the maddox bars of light from the large disc to the largest opening of the regular fixation light, which produced a band about an inch in width, by continual stimulation of retinal imagery, that forced itself through the thalmus into the parietal field of vision, bringing about a condition whereby it was possible for him to maintain a simultaneous perception of both bars in a crossed position, when neither of them was in motion. From this time forward suspenopsia absolute, rapidly changed into the lower orders of various periods of intermittency, finally to vanish entirely.

TREATMENT TECHNIQUES

I am very enthusiastic about instruments, plenty of them, the latest and the best obtainable, but in this instance, as in a great many others, there was nothing to be had which could bring about this type of stimulation of one eye in a manner which could be understood, and described by the patient, so well as this manual method. For succeeding cases of a similar nature, a rotary fixation target was attached to the Kratometer with a mirror arrangement. A strong light, back of this object induces either eye at will to perceive the rotary motion. Now these cases are all so linked in with phorias, and tropias that any adequate description bearing upon the purely intermittent vision necessarily involves handling by the phoric treatments.

It is often a problem how best to manage exophoric cases of from 1 to 5 prisopters, for there are some people whose vision is perfectly normal *to them*, not with the foundations expected of ½ ex but with 1, 2, 3 or 4 prisopters of exophoria, and any interference with this *personal normal* will not be acceptable. On the other hand, however, some of these very people are abnormals with these amounts. There is yet no known formula for typing, which can be relied upon in an impiric way for determining which is which. In making the tests for No. 4, whether with the maddox rod, vertical diplopia, the double maddox prism, or any other method, there is found an exophoric condition, and at the same time one of the fixation objects seems to disappear, we should immediately seize upon this warning reaction, and make one or more tests for intermittency as previously described. Now these exophoric cases frequently occur among early presbyopes, who have been subjecting their eyes to added accommodative strain at the time when convergence was also over-worked. These presbyopic cases are among our worst offenders, for they often add unexpected complications for which we are not prepared. If there is a tendency towards exophoria even of a smallish amount, we may uncover intermittency of the first or second order. There is often a complaint of discomfort and dissatisfaction either with bifocals or with mere reading lenses, for the eyes are working in relays to rest each other.

We have for a long time been familiar with the use of a pencil held midway between paper and the eyes, in what is styled "bar reading." With this bar it is necessary that both eyes watch the line of type uninterruptedly, while the subject *reads aloud*. If there is an interruption of vision of either eye, while reading with this bar, the patient will stop reading or miss a word, whereas, if both eyes function continuously, he will catch with one eye what the other eye cannot reach, and there will be no interruption in reading. The objections to the *pencil* is that it is too easily moved along and dodged. A head band was adopted with an arm extending out a few inches, and a bar extending down into the position of the pencil described. The purpose was the same, but the results were even worse, since the patient could merely move his head to avoid the bar. A better arrangement is that of a small metal grill affixed to a handle, upon which there is also a foot piece to rest upon the paper. The length of this foot piece maintains a fixed distance between the grill and the paper and makes it impossible to move it about. In the grill in use at the writer's office there are five bars in this instrument thereby producing five interruptions, instead of only one.

The patient who has a proclivity toward intermittent vision, may be considered to have acquired a bad habit of reading largely with one eye, so that his fixations along the line are not in proper sequence, and is not using one eye as a full assistant to the other. It is this habit we wish to overcome, and the handled grill places five interrupting bars along the line of type, so that at every position where a first bar interrupts a few of the letters, the other eye must be in readiness to pick them up and carry on. This is of course repeated by the second bar, third, fourth, and fifth in consecutive order, so that neither eye has any opportunity to lapse. This instrument is to be used for a quarter or half hour every day, and the patient should read aloud, even to himself, so that he may know positively by the sound of his own voice and *timing* that there is no interruption in the consecutive acts of fixation.

There is little or no doubt that the phenomenon of intermittent vision often positively indicates a fatigue case. Let us again reason a few moments upon the points concerned in the problem, and see if logical deductions may not follow. If I ask you to hold up a sheet of paper with your extended arm, you would do so without the slightest perceptible physical or mental effort, nor would you object if 20 or 50 sheets were laid upon your palm. Of course, after a few moments you would notice that there was a perceptible weight. I now lay upon your extended palm a small book weighing half a pound, or a pound, requiring you to hold it as long as you conveniently can. After a much shorter time fatigue would urge you to lower your hand, and rest your arm for a moment, after which you could raise it again for another interval. We will liken the first instance of a paper or two, to a *slight* exophoric state, and the small book to be 3, 4 and 5 prisopters of exophoria. Now if you were an anemic person, or you were of slight physical structure, or you were not in vigorous health you would notice this small weight far more

quickly, and fatigue would sooner become apparent by a certain painful sensation in the muscles of your arm, while on the other hand, if you were full of vigor your discomfort would not take place for a longer time. In the case of the small book, fatigue would ensue much sooner, and if I handed you a bulky dictionary, fatigue would be immediate. If you had a low and not unusual exophoria of 1, 2 or even 5 diopters, the small book would be a comparative illustration, while a large amount of exophoria, which it was entirely within your power to overcome by an excess of tension upon the internal recti, would be like the dictionary, for you could lift it with much effort as you also *can* overcome a considerable exophoria. But the amount of lifting one may do with the arm, or convergence effort with their eyes, are comparable, although fatigue will necessarily be earlier, and far more pronounced in the higher cases. We hesitate to use a simile in connection with the driving of a horse, since so few people are now familiar with the freaks of disposition of this useful animal, but for some reason which perhaps the horse knows better than the driver, there are those animals which do not stay on their own side of the road where they belong unless one rein is kept much tighter than the other so as to keep his head "gunned" to either the right or to the left as the case may be. This is precisely what a person experiences who has a controllable phoria, for he must keep a slight excess of tension upon that muscle which keeps the eyes properly fixed.

The greater the expenditure of muscular energy, the sooner our fatigue becomes apparent. Making application of these facts to the problems of intermittent vision, it is now apparent that the desire of the mind to see binocularly, while also being under the handicap of factors which produce early fatigue, will soon give rise to an impulse of relaxation, which of course would mean diplopia, and which would be intolerable, for two images of the fixation points in different positions instantly gives rise to a faulty conception of the actual position. The normal impulse will be for the mind to ignore *one* of these pictures. Now the mind is not satisfied with one picture if two can *possibly be* had, and an early attempt will be made to resume vision in the eye which suspends. The logical deduction of this state of physical, nervous, and mental reaction is that these moments of interruption are indicative of resting periods, sufficiently long for relief from fatigue. This is usually the type of intermittency we encounter in any of the phoric cases. We have mentioned suspenopic conditions where there was a difference in the amount of astigmatism, or an antagonism in the axes, or a difference of retinal sizes of images. This is of course a fatigue not of the extrinsic muscles but of the ciliary, whose function it is to equalize and compensate astigmatic axes and retinal picture sizes. It is a well known fact that either of these causes of fatigue do produce intermittency of one or both eyes.

There are two schools of thought in regard to the handling of these phoric cases. There is nothing new in the exercise method of building up physical ability in muscles by rhythmic exercises by the use of prisms, either the risley's the Kratometer, or some of the recent mechanical de-

vices, since these have been in successful use for more than half a century. The other method of course is the application of a prism which has sufficient power to relieve the most burdensome amount of deviations, although we should use only the smallest practicable amount because of the weight which will be introduced, and a tendency toward color fringe. Only on rare instances, however, will more than 3 or 4 diopters be indicated, and it is surprising to find that ½ to 1 diopter often affords ample relief to cases exhibiting a considerable phoria. One who asks for help, wishing some one would "give them a hand," does not want the *whole* burden carried, but merely just a tiny lift. There is no objection whatever to the use of prisms. All lenses are a combination of prismatic power, either base-central, as in plus spheres, or apex-in, as in minus spheres, while the prisms here advocated are the simplest variety, perfectly harmless in all respects. The sole purpose is to slightly ease a burdensome condition, and often after a few weeks or months, the defective function will have so far recuperated that the prism may be removed.

Perhaps it is slightly out of place in this paper upon intermittency, to take up the subject of eye dominance, and discussion before which eye a prism should be placed. People are commonly right or left handed, or eared, or footed, and are also normally right or left eyed. The dominant or "leading eye" is the normal fixator by which the mind points directly at the object of regard, and the other eye is merely an assistant. We rely normally upon the location of objects as first fixated by the dominant eye, and depend upon the assistance which the non-dominant eye can render. The prism should be placed before the non-dominant eye, unless for some reason this rule needs to be violated. If the visual acuity of the dominant eye is far below that of the non-dominant the prism should then be placed before the dominant eye. There is less disturbance to mental equilibrium and the line of fixation if only the visual axes of the non-dominant eye is redirected. There is no sense whatever in following the ancient rule of dividing the prism between both eyes. Prisms which are properly ground are nearly invisible, or at least are very inconspicuous. If the prism is to be placed in a frame, its belt line should be very close to its front edge, so that the heavy portion will be behind the rim, and quite concealed. A similar manner of treatment should be followed with the rimless type. A practical way to determine which is the dominant eye consists in punching a pencil through a piece of paper, requiring the patient to hold it with *both* hands, *the arms extended as far as possible*. When we have secured this position, the patient is next required to look at some object of fixation with both eyes wide open. We now hold a card or some obscuring object before first one eye and then the other, to learn which eye is thus shut off. This both-arm extension method of holding the paper avoids from right- or left-handed dominance, so that we secure right- or left-eye dominance independently. Many of our customs and habits of eyes are due to a prevalent right handedness, and many tools or instruments are built with this primary

idea. The left handed person is sometimes much handicapped because of this attitude, and finds it necessary to readapt his habits.

Whatever conditions of this nature which apply to the use of the hands and arms should not necessarily be continued in acts of vision for only by a full binocular function are we fully capable of using this faculty. The slight handicaps which hyperopia, myopia, and astigmatism may introduce, or a somewhat burdensome phoric condition, all of which are correctable, ought not to be allowed to handicap the visual function. It is at this point where our present emphasis comes to the front in regard to orthoptic/orthophoric training, in addition to the use of ophthalmic lenses. There is an inherent "laziness" in everybody, and this laziness may take on one or many forms. If we can do a thing as easily with one hand as with both hands, the lazy hand will be found folded in the lap, and the lazy eye may be practically folded up, or at least its owner does not make full use of it. This is more likely to take place with people who have some visual defects, than with those whose eyes are both perfectly capable. But although the eyes have been individually very carefully corrected, this lazy habit, however acquired, is quite likely to carry along, and it is our purpose in rectifying the case for their work to correct these faults.

Within certain reservations intermittency may be considered as a false habit, which it is our purpose to overcome by imposing a series of corrective reactions, as it will not cease until a time when the visual faculty of such an eye can be brought to useful acuity, and also properly positioned so that its image is fusable with that of the other eye, and not only must it be *possible* to fuse it, but it must be brought within the comfortable, and easy range of effortless fusion. While our problem is primarily to make vision possible, to improve vision, it is also necessary to balance the phoric state so that effort is not constantly demanded for fusion.

In myology our first concern is the training of the orbital muscles into a functional relationship they have probably never experienced in the whole life of the patient. A child having internal strabismus may perhaps have half his iris under cover, and our first exercise must be directed toward wide excursive eye movements.

The test for ocular poise is obtainable "statically" in our common methods of the maddox bar and point of light, or by the double prism diplopia method, and "dynamically" by the gradual application of prism power, apex-in to stress the interni, and apex-out to stress the externi to breaking points. As in many other ways we have always reasoned upside down, and backwards, like a Chinaman, since in the use of prisms to measure the power of the recti, the base side to which we constantly refer is the side of "rest" or inhibition, whereas we are in search of the functional *reserve* power of those muscles adjacent to the apex. This old *base method* dates back 250 years to Sir Isaac Newton, who first investigated the dispersion of light, and found that a beam "bent

in the direction of the base," and we have followed the path of this famous scientist ever since by talking base, and reasoning backwards. I am here suggesting a very clear graphic method of showing the power of the interni "apex-in" to the breaking and recovery point, apex-out, stressing the external recti to the breaking and recovery point, and the sup-inf recti to break and recovery with distance fixation, as indicated above the horizontal line. At near point fixation these break and recovery numbers are shown placed below line. The appropriate foundation test numbers are marked in red in their proper positions. There is also shown the toleration of the accommodative stimulation. This graph can be readily drawn upon any chart for rapid use on those cases to which we wish to refer quickly without studying the whole field. The graph mentioned will show both the static and dynamic conditions, the latter both under the static accommodative condition for distance as given above the line, and the dynamic conditions below the line.

There is a form of intermittent vision which is the bane of foundation conditioned reflexes under the various phoric tests for so-called "binocularity." Data is taken for positive and negative reserve fusions (with) apex-in and apex-out prisms. It is a common occurrence, when the risleys are rotated for the measurement of the interni, to have the patient apparently maintain binocular functions up to the full power of one, and sometimes both cells of risleys without breaking, so as to cause the sensation of diplopia. However, when we turn the risleys back toward zero, even though the rotation is exceedingly slow over each eye, the patient will suddenly exclaim "now I see two objects," when the prisms have approached well toward zero. We are usually dissatisfied with this first test, and repeat it with strict injunction to watch *very* carefully for diplopia. Again the whole procedure is like the first, with the apparent inability on the part of the patient to discern any *break* of fusion, yet he again suddenly picks up this second image or return as before. It is quite apparent from observations repeated over thousands of cases, that one of the eyes suddenly shuts off, and does not resume function until the stress imposed has been reduced to low limits—probably the lowest limits of toleration. These cases are likely to exhibit quite low fusion power. Blurring begins at different prismatic powers in various patients, some tolerating much more than others before the blur-out level is perceived. However, after having carried the prismatic power far beyond the blur-out point so that even large letters are unreadable, we fail to make the patient perceive two illuminated areas, for he still insists that the picture is single. Now by a moment's reasoning it is quite evident that this blurred retinal picture belongs to one of the eyes and is extinguished somewhere between the retina and the mind. This is another case of evident binocularity and monoptralcy, for there is no possible doubt of the existence of two retinal images, even though the patient receives but one, and does not know which one is being sensed. A rather large number of subjects exhibit this phenomenon with a very small amount of prism, and these cases often balk our work of typing.

Certainly this is not "suppression," a purely voluntary act, but a case of "suspension" which is far beyond the will power of the most resolute and determined person to control. Perhaps this can be further explained by a case of a young woman who had a right exophoria which varies from 5 to 10 prisopters according to her fatigue conditions. Without a corrective prism before her left eye she has an inclination to suspenopsia, but having used this corrective prism for over a year with considerable comfort she still feels a lack of coordination of this left with her dominant right eye. With a corrective 6△ apex-out prism before the left eye she breaks fusion at 12 prisopters, recovering at anywhere from 1 to 4 prisopters, and with apex-in break and recovery are at 7 to 10/.4 prisopters. It was with the utmost difficulty, however, that these figures were obtained, for fusion would often break without her knowing it, and it was not until the powers were reduced to a comparatively small amount before diplopia could be sensed.

Some cases of this type are so physically constituted that there seems to be a lack of turning power of the muscles. We are unable to trace them to any injuries of the head, the eyes, or the muscles, either at birth or due to some accident, but there is doubtless a lack of development of the fusion faculty itself. Using any of the means for horizontal excursive movements of the eyes, such as holding an ophthalmoscope lamp in its handle two feet from the patient, and moving it from side to side over a wide arc, so that the eyes must turn in their sockets to the utmost limit, we can frequently develop a freedom of muscle movement and motor neural control.

Again the two parts of corrective procedure in this orthoptic/orthophoric work is apparent, for not only must the eyes have sufficient rotative ability to fixate normally at infinity without effort, but also at the point of convergence with plenty of reserve in each instance. This condition of interrupted vision can not be overcome merely by the addition of a prism for constant wear, or rotational exercises for the neuro-muscular system, but we must go further and overcome false habits in the perceptive faculty. The writer devised an attachment for the Kratometer in which a small electric clock motor was placed in a case above the head of the patient. On the shaft of this motor is fastened an illuminated disk which revolves at a speed of about 50 revolutions per minute. Upon this disk are some curved white lines whose purpose it is to call attention to a central point which rotates in a manner which draws the eyes toward its middle spot. This object is reflected upon two mirrors, back-hinged in the center which are under control of the patient. While the disk is rotating he pulls slowly upon a cord extending from each of his right and left index fingers to these two mirrors. By controlling the reflected images in the mirrors he converges them until fusion takes place, then relaxes until fusion breaks, repeating this process for a ten minute period. Now sense of movement in the Periphera of the retina is the primary function of sight which serves to claim attention, and the centripetal

target movement brings attention strongly towards macular perception. This has proved very effective in breaking down Intermittency of those cases where it was difficult to maintain binoptralcy. After a few treatments of this type, and as soon as the function of binoptralcy is well established, we can then resort to still objects which require the undivided attention of the mind through both eyes. For this purpose the (Reflectoscope) or the Streo-orthopter, by the American Optical Co. or the Maddox Cheiroscope made in England, are valuable. With these instruments a still picture is so placed before one of the eyes that its image is seen by one eye and carried to the mind. The patient now takes a pencil, and while looking with one eye, through the other eye-piece of the instrument, toward a piece of white paper, proceeds to outline the picture projection with his other eye. He sees with one eye, transmits the single retinal image through the optic thalmus, the optic radiations into the calcarine fissure of the brain where it is subjected to the mind, transferred to the opposite side of the brain and along the radiating fibers to the other side of the optic thalmus, and thence projected upon the white paper for tracing. Now this also brings in the motor function, which controls the hand and arm in close association with the several eye muscles so that a close cooperation of both sensory and motor faculties are compelled to function. Should there be a suspension of vision so that the picture is invisible to the mind it cannot be drawn. Or, should suspension of the eye directing the drawing occur, the lines which the hand draws, as well as the pencil itself, will vanish. Now these Intermissions may last but a moment, or they may be more enduring.

However, a patient who makes considerable effort can draw his mental attention to the picture itself should they vanish, by moving his own finger or pencil in the field of view, because "motion draws attention." Or, should the drawing, the pencil, or his hand be interrupted he can bring attention again to perception by wiggling the pencil rapidly until suspension ceases. Thus by using the device first described, of mechanical movement upon the Kratometer, followed after a few exercises by these drawing lessons, we are generally soon able to gain the upper hands of Intermittency. Of course, it is well understood that during Intermittency one has no stereoscopic sense.

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THE OPHTHALMOSCOPE AS AN AID IN REFRACTION

The very large number of cases refracted annually by optometrists, afford these refractionists an excellent opportunity for ophthalmoscopic study. With proper ophthalmoscopic equipment, both regular and red-free, the variations of the normal fundi may easily be studied and recognized. Congenital anomalies must always be kept in mind, lest they be classed as pathologic and unnecessary treatment suggested. Much has been written on the important subject of an ophthalmoscopic examination in every refractive case and in the offices of a great majority of optometrists the routine use of the ophthalmoscope in case after case is taken as a matter of course.

However, the ophthalmoscopic examination is for the most part made by these optometrists solely to determine the presence or absence of indications of, or departures from normal, in the interior media and tissues of the eye. As a rule optometrists do not attempt to determine by means of their ophthalmoscopic examinations an approximation of the amount of spherical or cylindrical error present in the eye under observation. This is true, probably because of the lack of exact accuracy of this technique when compared with skiascopy. However, in the opinion of the

writer, no optometrist should omit this important step in his examination of the patient for ametropia.

The transparency of the aqueous, lens and vitreous, the condition of the retinal vessels, a careful study of the disc and macula, as well as the general eye ground or fundus as far toward its periphery as possible will give the optometrist knowledge which is indispensible to him. In addition, a study of the ametropia present in this same eye will add a small sum to his basic knowledge of the refractive status of the case, and will serve to check the other purely refractive tests which are to follow.

A number of years ago, Loring, one of the real fathers of the art of ophthalmoscopy, said, "Five-sixths of the art of ophthalmoscopy is contained in the knowledge of the normal eye, the rest is a series of representations which can be read almost at sight." A knowledge that comes only with practice, and practice which will be materially enhanced by the two-fold use of the ophthalmoscope, both as a diagnostic instrument and as an aid in determining the refractive conditions present in each case.

As I have said, practice in measuring the refraction of the eye by means of the ophthalmoscope is a useful aid in diagnosing the pathology of the eye. For most optometrists at least, an approximation is possible. For a few, particularly those who have the advantage of presbyopia, even a certain degree of accuracy may be obtained. A certain degree of care and attention exerted in studying and applying the principles involved in making this test will enable the optometrist to estimate with no little accuracy the errors of refraction present and will also incidentally, enable him to estimate for instance the amount of swelling or excavation of the optic disc, or the level of retinal detachments, or intraocular tumors, or what is of much more common experience, the position of various lenticular or vitreous opacities.

To measure the refraction of the eye by means of the direct method of ophthalmoscopy the accommodation of both the patient and the optometrist should be as nearly at rest as possible. The room should be darkened and the patient placed in a somewhat reclined position looking off at a far corner of the wall or ceiling, thereby relaxing his accommodation voluntarily. The optometrist may be able, after some practice to also relax his accommodation while viewing the interior of the eye by means of the ophthalmoscope. This does take some practice but it is by no means impossible and many refractionists can do this at will. In observing the interior of the eye the optometrist should wear a correction for any errors of refraction which may be present in his own case, and should in making a direct ophthalmoscopic examination hold the ophthalmoscope as near the eye as possible.

In emmetropia the parallel rays of light, emanating from the patient's eye, are accurately focused on the retina of the emmetropic observer. In hyperopia the divergent rays of light, emanating from the patient's

eyes, are converged by a convex lens of sufficient strength in the ophthalmoscope to produce parallelism. The parallel rays are then received accurately on the retina of the emmetropic observer.

In myopia the convergent rays of light, emanating from the patient's eye, are diverged by a concave lens of sufficient strength to produce parallelism of the emergent rays. The strength of the convex lens in the ophthalmoscope in the one case, and of the concave lens in the other, determines the amount of hyperopia or myopia, respectively. A variation of the accommodation on the part of the patient or the observer always adds to the apparent myopia or reduces the hyperopia which is present in the case under observation. Because of this, the strongest convex lens in hyperopia or the weakest concave lens in myopia which permits the emmetropic observer a clear image of the retinal vessels, approximates most accurately the total error of refraction. Certain amounts of ammetropia correspond to given lengths of the axial diameter of the eye. Therefore, if one is able to estimate the refraction of a given point and compare its location on an anteroposterior diameter with another given point, the difference in depth of any two points may be estimated.

In an astigmatic eye small retinal vessels which run parallel to the two principal meridians must be brought into focus individually. The measurement of a vessel parallel to the 90 degree meridian, for example, gives the refraction of the eye in the 180 degree meridian, i.e., vessels seen clearly in one direction give the refraction of the eye at right angles to that direction. This estimation should be made by the measurement on small retinal vessels running at right angles to one another. The difference between these two estimations gives the amount of astigmatism present in the case under observation.

These techniques are easy to master and in so doing the optometrist will also become thoroughly familiar with every phase of ophthalmoscopic procedure and thus place himself in the position of a practitioner who can give his patients the fullest diagnostic service possible from both the standpoint of refractions and pathology. Most optometrists are already good diagnosticians when it comes to the matter of differentiating the normal eye from the one that has developed some abnormality. By a little practice every optometrist not only can do this important work but can also become proficient in the art of estimating the error of refraction while making his ophthalmoscopic examination. Carel C. Koch.

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BOOK NOTICES

REFRACTION OF THE EYE. Alfred Cowan, M.D., Associate Professor of Ophthalmology, Graduate School of Medicine, University of Pennsylvania. Published by Lea and Febiger, Washington Square, Philadelphia, Pa. 3 colored plates, 172 illustrations, 319 pages. Cloth $4.75. 1938.

This is a well written ocular text book. Cowan developed the

material found in this volume from his lectures on ocular refraction and the physiological background presented by him for the tests employed in making ocular examinations. The book divides itself equally into two sections, the first of which deals with the theory of optics pertinent to refractive work. Here the writer goes into considerable detail reviewing the experimental work done to fully cover the subject and to present a clear understanding of the science of optics as it applies to ophthalmic lenses and their use. The second portion of the work deals with ocular abnormalities and their optometric correction. Cowan does very well here, and his chapters on objective and subjective testing are well written and easily understood. For instance, such subjects as "The Resolving Power of the Eye," "The Relation Between Visual Acuity and Illumination," and the "Determination of Visual Acuity," while brief, are complete and in each instance fully explain the points to be covered. The author mentions the refractive techniques employed by Sheard and Cross and some of the new developments in the correction of sub-normal vision by Feinbloom. The only possible omission in this well written text comes in his chapter on Dynamic Skiametry where the newer techniques of Edwin Forbes Tait have been overlooked. Despite this omission, this is a text well worth the attention of every optometrist.

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